Welcome!!

Mobile Networked MIMO (MNM) Workshop

14 September 2005

Stephen Griggs
Program Manager
Stephen.griggs@darpa.mil

MNM Workshop
Agenda

0800-0900	Registration	
0900-0945	WNAN	Preston Marshall, PM
0945-1000	MNM Overview	Steve Griggs, PM
1000-1020	Research Issues & Opportunities	Brian Sadler, ARL
1020-1040	S&T CD Technology Transition Overview	John Pusterhofer, CERDEC
1040-1100	Break	
1100-1110	Ashutosh Sabharwal	Rice University
1110-1120	Beau Beck	Airgo Networks
1120-1130	Homayoun Yousefizadeh	Boeing
1130-1230	Lunch	Poster Session
1230-1240	Tong Zhang	Rensselaer Polytechnic Institute
1240-1250	Peter Rogina	WorldScape
1250-1300	Ajay Gummalla	SDRC
1300-1310	Hlaing Minn	University of Texas at Dallas
1310-1320	Robert Leng	WikiTek
1320-1340	Break	
1340-1350	Joe Liberti	Telcordia
1350-1400	Babak Daneshard	Silvus Communications
1400-1410	Robert Taylor	MITRE
1420-1430	Langhorne Withers	MITRE
1430-1440	Sang Kim	Iowa State University
1440-1450	Chang Chen	Florida Institute of Technology
1450-1500	Elza Erkip	Polytechnic Institute
1500-1510	Robert Mainhart	CERMUSA
1510-1530	Closing Comments	Steve Griggs, PM MNM

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Today's Objectives

This is a "workshop", we are not talking money

We <u>are</u> talking: *"Mobile Networked MIMO for Military Applications"*

I hope to:

- Find out who is interested in military MIMO
- Discuss the future of military MIMO systems
- Develop metrics that help us understand progress
- Encourage the growth and development of military MIMO
- Road test my vision for future MIMO efforts

The Military Needs New Radio Technology

Our user needs more bandwidth and better reliability

Little Has Changed in Radio Physical Layers Over the Last Several Decades

- **Primarily Voice Comms**
- **Same Bands, Same Bandwidths** (though smaller and more secure)
- **Digital Modulations Have Replaced Analog, but Little Change in Functionality**

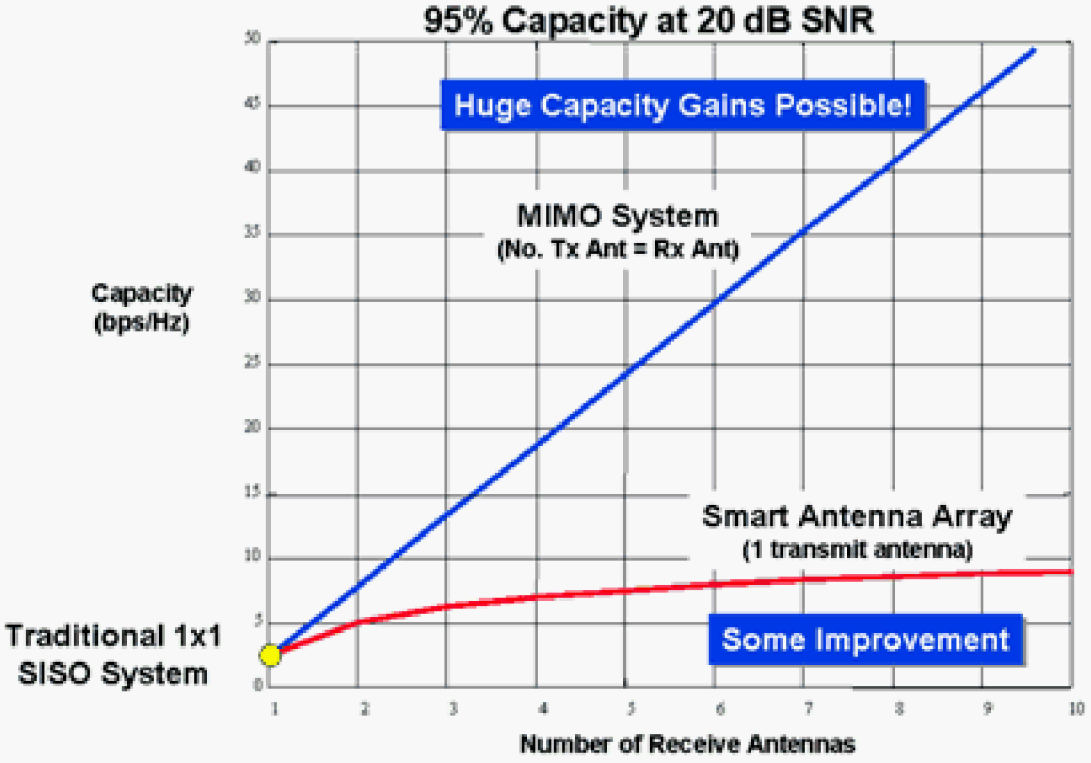
No Significant Physical Layer Innovations in the Acquisition Pipeline

- **Same Bands, Same Bandwidths** (though some additional networking and throughput)
- **No Additional Range Over Existing Radios**
- **Spectral Efficiency Still Poor**

Mobile Networked MIMO is the answer!

Mobile Networked MIMO
Adapting MIMO for Military Use

Multiple-Input, Multiple-Output (MIMO) communication systems have the potential for a 10-20x improvement in channel capacities in the spectrum limited JTRS bands under dynamic urban NLOS multipath channel conditions where conventional techniques degrade

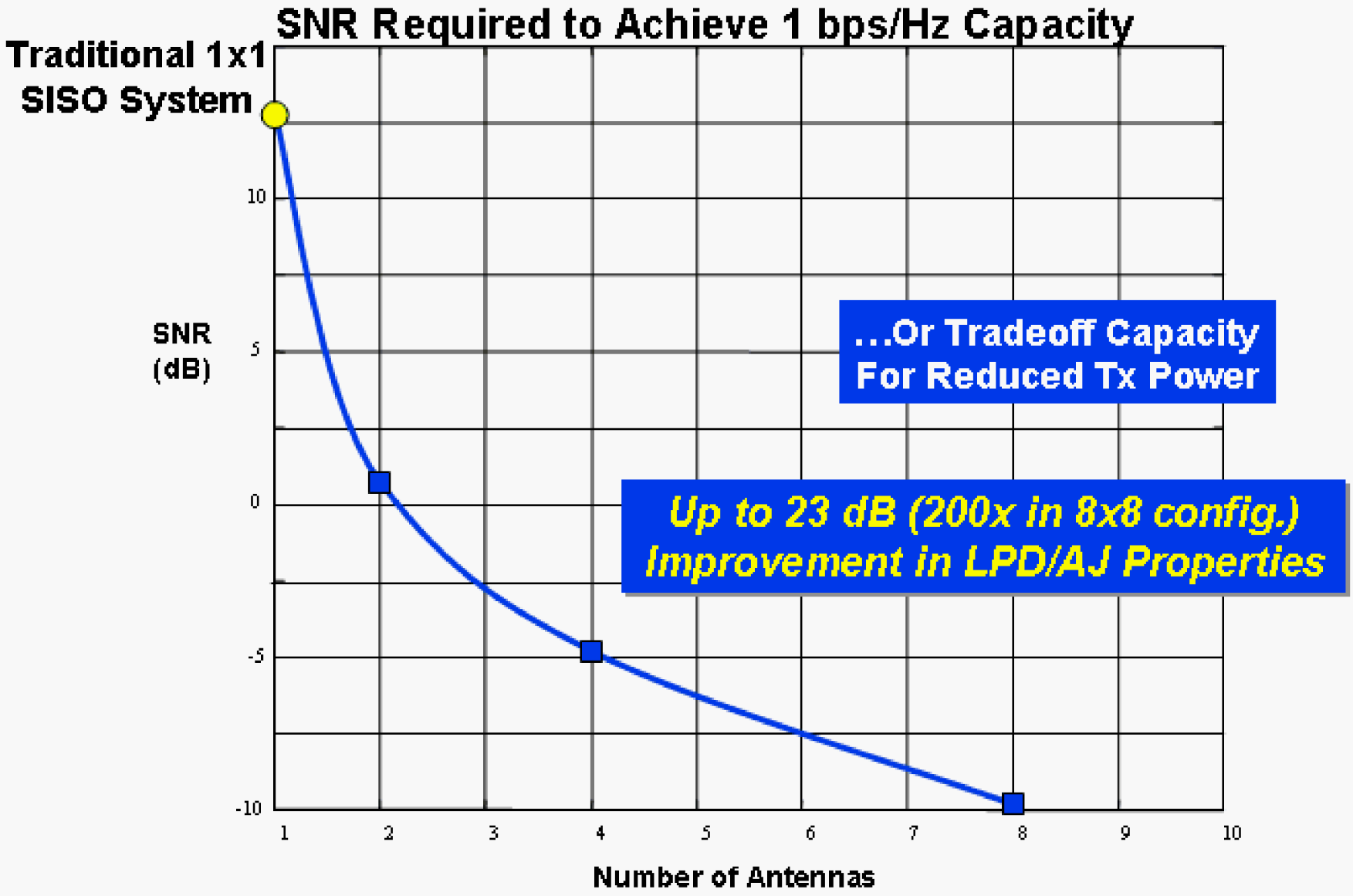


MIMO Can Be Adaptable

- Mobility: Mounted and Dismounted
- Data rate
- Frequency
- Bandwidth
- Anti Jam
- LPD
- Channel utilization
- Antenna number and placement
- Urban and rural

MNM Takes Advantage of the Adaptability of MIMO

MIMO Capacity Can Be Used In Other Ways…



MNM PHY Testing at NAES Lakehurst

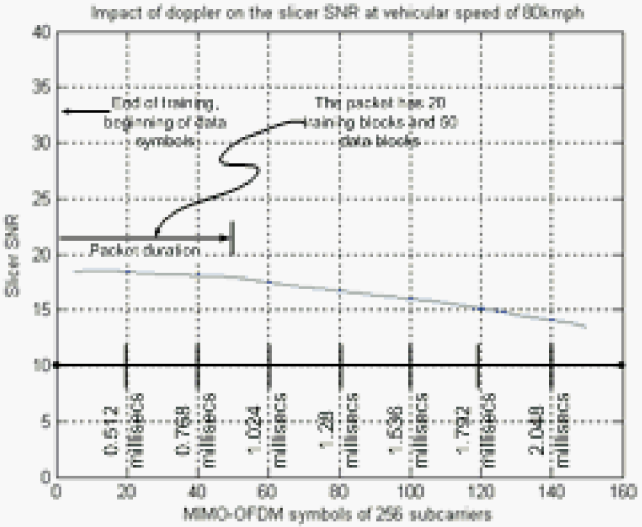
- Demonstrated Mobile MIMO
- Multiple MIMO Configurations of 8x10, 4x10, 2x10, 1x10, 2x2 and 1x2
- Line-of-sight and Non-LOS
- Demonstrated up to 40 mph

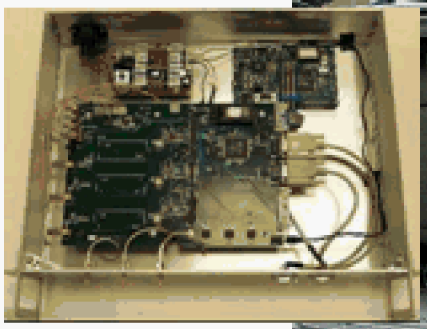
Mobile MIMO Physical Layer Works!

MIMO SBIR Hardware Tests and Modeling

20 MHz 2x2 burst MIMO at 160 Mbps peak - Low mobility

Cf = 900 MHz
B = 25 MHz
V = 80kmph

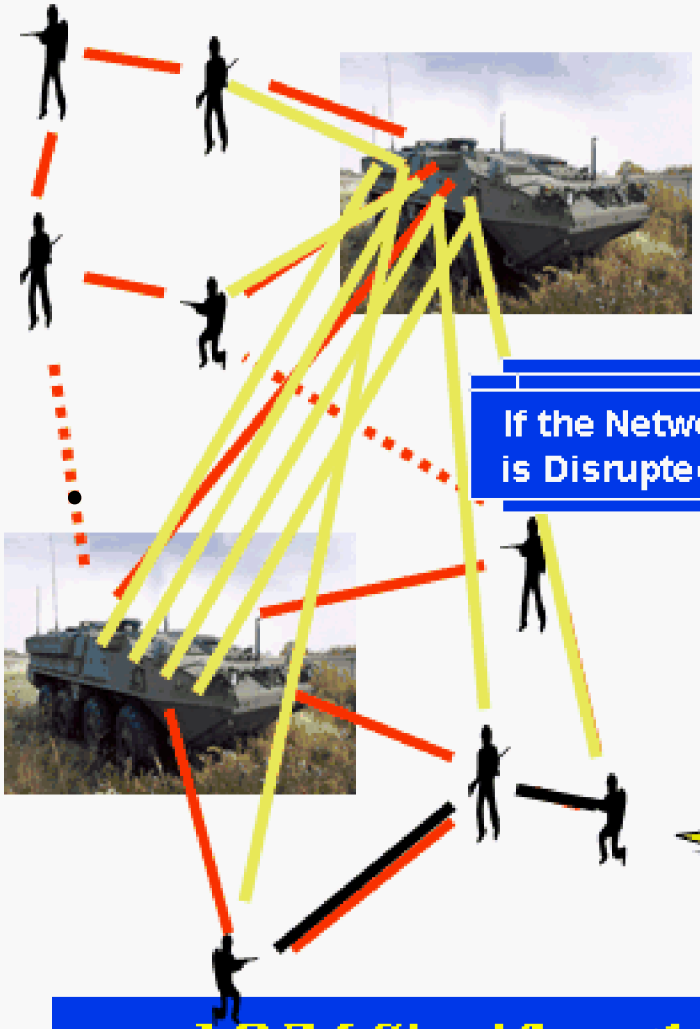




High Mobility (>70 MPH)

- 3x4 system operating at 220MHz carrier frequency
- 4kHz RF bandwidth
- Highly programmable
  - Variable power, multitude of modulations and demodulation algorithms

MNM: MIMO to the Soldier



MIMO exploits the spatial diversity (multipath) created by having more than one T/R unit and antenna at each end of a radio link.

This diversity can be used:

- With spatial multiplexing to achieve higher data rates
- Improve AJ/LPD performance
- Reduce power consumption
- Trade off for more simultaneous channels
- Allow more reliable communications

Radios can be ganged together to increase performance

- Data rate adapts linearly, range increases, and/or improved LPI / AJ / Security
- All adaptively traded – scaled as MIMO capability is combined by combining radios

DARPA Payoff

- Realizing the potential of the dynamic degrees of freedom in MIMO PHY
- Developing MIMO aware ad-hoc network

MNM Significantly Improves Data Rates and Reliability

Key Technology Areas / Metrics

Practical Implementation
- Size
- Power
- Antenna count and placement

Adaptable waveforms
- Spectral efficiency
- Data rate, Frequency. Bandwidth
- Dynamic security approaches
- Reaction to Interferers
- Channel utilization

Urban and rural environments

Mounted and Dismounted nodes

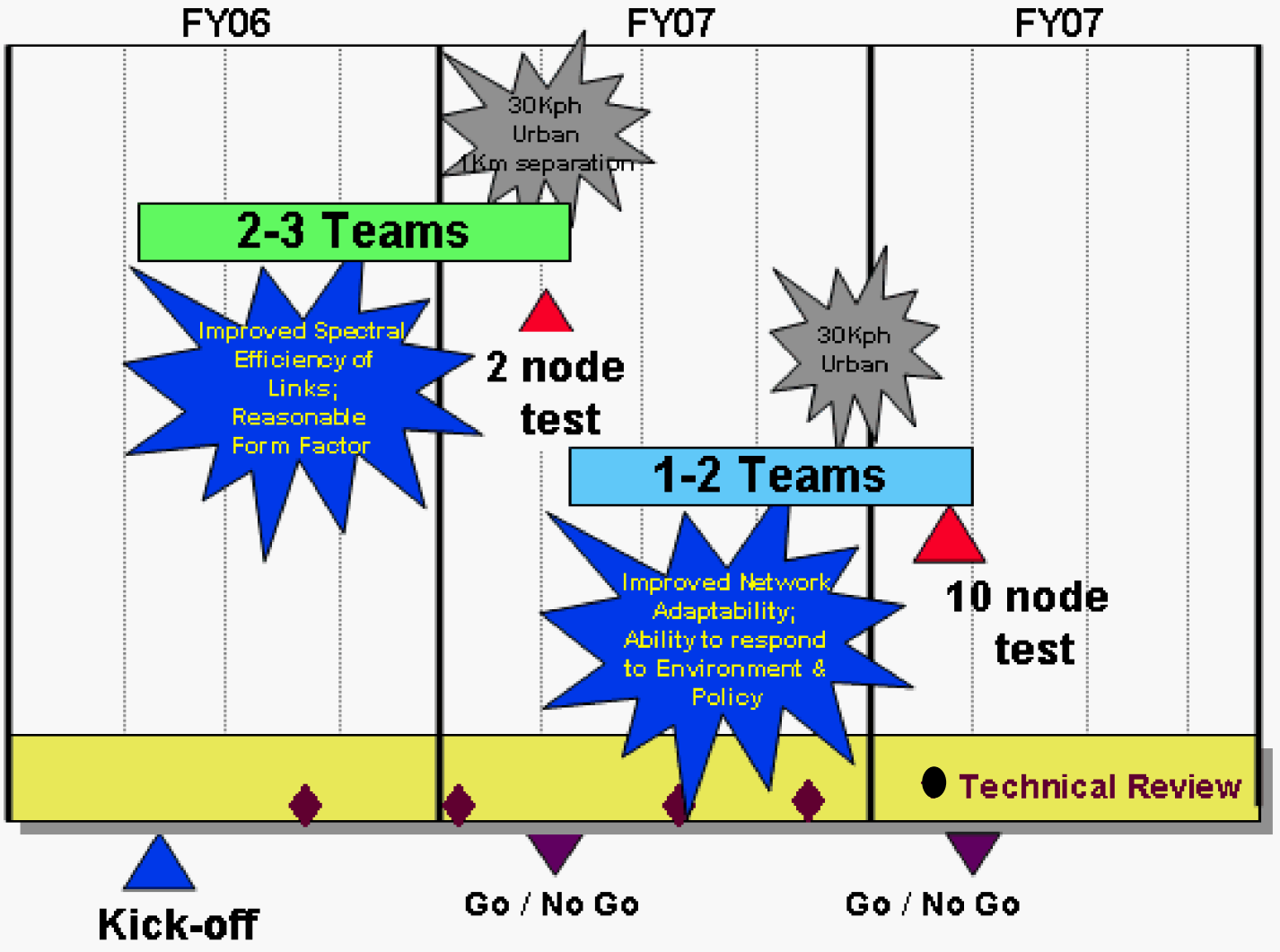
Key Metrics
- **20 bits/sec/Hz to force efficient use of all bandwidths in high-data rate modes**
- **SWAP to fit in a military vehicle**
- **Adaptable waveform**
  - Must be able to trade throughput for AJ / LPI
  - Must be able to adapt to the environment

Challenge is to provide enough processing (computing and A/D conversion) in real-time in a form factor suitable for tactical environments with enough intelligence in the network to effectively utilize Mobile MIMO in an extremely adaptive way so the network can respond to changes in the environment and security policy in a spectrally realistic manner with enough throughput to support military applicability

Nodes

- Two types of nodes: Mounted and Dismounted
  - Both use the same TR modules, but different numbers of them
  - Dismounted nodes will have two TR's
  - Mounted nodes will have a max of eight
- Mounted nodes must fit within the current vehicle radio space, power, and cooling envelope
- Dismounted nodes must be no larger than their current radios

Notional Program Plan



MIMO to the Soldier

- We need to develop a radio system designed from the ground up for data network operation
  - It must provide the connectivity the soldier needs
  - It must supply the necessary data rate
  - It must fit the soldiers environmental and supply realities. (size, weight, power, cooling, antennas, etc)
  - Above all, it must be reliable
- MIMO has the promise to be an enabling technology for this networked system
  - It can support spectrally efficient, high data rate, mobile (mounted and dismounted), networked capability
  - It can adapt to the environment and the mission

We will need your help to make this vision a reality